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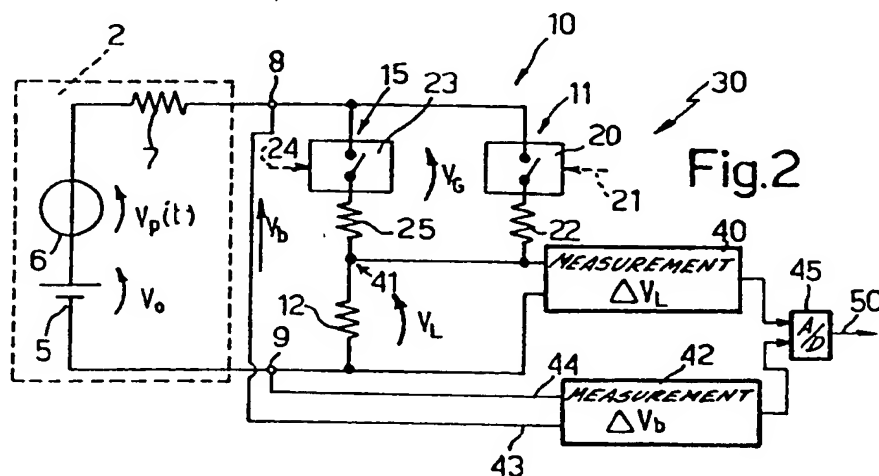
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(54) A device for measuring the internal resistance of batteries, particularly of motor vehicles.

(57) The device comprises a measuring circuit (10) which includes a resistive load (12) connected across the terminals (8, 9) of the battery (2) via an alternating voltage generator (11) which switches the load at a predetermined frequency; a unit (40) for measuring the variation (V_L) of the voltage drop across the load due to the switching of the said load; a unit (42) for measuring the variation (V_b) of the voltage drop of the battery caused between the terminals of the battery by the switching of the load (12) and a unit for calculating the internal resistance in relation to the variation of the voltage drop of the battery and the variation of the voltage drop across the load, with the relationship being parameterised with respect to the resistive value of the load.



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This invention relates to a device for measuring the internal resistance of batteries, particularly of motor vehicles.

As is known, the internal resistance of a battery depends specifically on the temperature, on the state of wear of the battery, and also on the density and the level of the electrolyte, i.e. on the state of charge of the battery. It therefore represents a significant parameter which can be used for the diagnosis of the battery itself. This leads to the requirement of being able to measure the internal resistance of a battery in a simple and reliable way.

A known instrument for diagnosing the state of wear of batteries based on their internal resistance comprises a circuit which is connected to the battery and which generates an output voltage or current proportional to the internal resistance of the battery. The value of the output voltage or current is measured and displayed by means of a needle indicator, which can be calibrated so that it directly indicates the level of wear of the battery according to the position of the needle. Such a known instrument, which has a knob for manually setting the temperature of the battery to compensate for the effect of the latter on the internal resistance, is disadvantageous in that it does not enable the value of the resistance to be read directly, and most of all, moreover, in that it does not have a good resolution and is subject to the errors in reading which are typical of this type of device and which are associated with oscillations of the needle, which prevent an accurate value from being read off.

The object of this invention comprises the creation of a device for measuring the internal resistance of batteries which removes the problems of the known instrument, and which provides the accurate value of the resistance at its output, which can be displayed directly without requiring needle instruments to be read.

According to this invention a device is created for measuring the internal resistance of batteries, particularly of motor vehicles, which is suitable for connecting to the terminals of a battery, characterised in that it comprises:

- a resistive load connected across the battery terminals via switching means suitable for switching the said load at a predetermined frequency, the said load having a predetermined resistance value and producing at its terminals a voltage drop across the load which varies with the said frequency;
- suitable means for determining the variation of the said voltage drop across the load;
- suitable means of determining the variation of the voltage drop of the battery across the said battery terminals; and
- suitable means of calculating the internal resistance in relation to the variation of the said voltage drop of the battery and the said variation of the voltage drop across the load, the said relationship being parameterised with respect to the said resistive value of the said load.

To provide a better understanding of this invention, a preferred form of construction will now be described, purely by way of a non-limiting example, by means of the accompanying drawings, where:

- Figure 1 is a simplified circuit diagram of the circuit used in the device of Figure 3;
- Figure 2 is a more detailed circuit diagram of this circuit;
- Figure 3 is a block circuit diagram of the device according to the invention, incorporating the circuit of Figure 2; and
- Figure 4 is a flow diagram relating to the calculation of the internal resistance.

Figure 1 shows a simplified circuit diagram of a circuit 10 which forms part of this measuring device, to illustrate the principle on which the invention is based. The circuit 10 of Figure 1 is connected across the terminals 8 and 9 of a battery 2, the equivalent circuit of which is represented as comprising the connection in series of a first generator 5 of DC voltage V_0 , of a second generator 6 of voltage $V_p(t)$ and of a resistor 7 of value R_I ; in this schematic diagram, the voltage V_0 represents the electrochemical potential ($12 \text{ V} \pm 5\%$), the voltage $V_p(t)$ is the voltage drop due to surface charges; this voltage drop is positive after charging and negative after discharging the battery, varies slowly with time with respect to a rapidly alternating (100 Hz) voltage component, and must be considered as zero for dynamic purposes; finally the resistance R_I represents the internal resistance of the battery, which is not affected by transient polarisation phenomena but is inversely proportional to the area of the elements and to the capacity (dimensions of the plates) and increases when the battery is discharged (by electrolysis or by sulphate formation).

The circuit 10 comprises the connection in series of an alternating 100 Hz generator of value V_G and a known, stable, resistive load 12 of value R_L , which is switched by the generator 11. The following relationship is valid for the circuit of Figure 1, where $I(t)$ denotes the current flowing in the battery:

$$V_G(t) = (R_I + R_L) \cdot I(t) = V_p(t) + V_0 \quad (1)$$

Differentiating with respect to time gives:

$$dV_G(t)/dt = (R_I + R_L) \cdot dl(t)/dt + dV_p(t)/dt +$$

$$dV_0/dt \quad (2)$$

5 which with

$$dV_p(t)/dt = dV_0/dt = 0$$

under dynamic conditions gives:

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$$dV_G(t)/dt = R_I \cdot dl(t)/dt + R_L \cdot dl(t)/dt \quad (3)$$

The substitution:

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$$R_L \cdot dl(t) = -dV_L(t) \quad (4)$$

gives:

$$dl(t) = -dV_L(t)/dt/R_L \quad (5)$$

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and substituting (4) in (3) and solving for R_I gives:

$$R_I = [dV_G(t) + dV_L(t)]/dl(t). \quad (6)$$

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Substituting (5) in (6) gives:

$$R_I = - \frac{dV_G(t) + dV_L(t)}{dV_L(t)} * R_L \quad (7)$$

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Moreover, since $V_G = V_b = V_L$, (7) may be rewritten as

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$$R_I = - \frac{dV_b - dV_L + dV_L}{dV_L} * R_L \quad (8)$$

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and therefore:

$$R_I = - \frac{dV_b}{dV_L} * R_L \quad (9)$$

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It follows that it is possible to determine the internal resistance of the battery by obtaining the variation of V_b and of V_L , and with an accurate knowledge of the value of R_L .

50 A more detailed circuit diagram of the circuit 10, and of the components intended to obtain the variation of V_b and of V_L (measuring device 30), is shown in Figure 2 and will be described below.

In Figure 2, the elements which are common to the simplified diagram of Figure 6 have been given the same reference numbers. In particular, the battery 2 is again represented schematically by the generators 5 and 6 and by the resistor 7. The load is again defined by the resistor 12; in series with the latter a connection of two branches in parallel is provided: one comprises the alternating generator 11, and the other defines a branch 15 for eliminating surface charges. These branches are thus interposed between one terminal of the load resistor 12 and the battery terminal 9.

55 In detail, the branch 11 comprises a first controlled switch 20 provided with a control terminal 21, and a suitable resistor 22 connected mutually in series. The branch 15, on the other hand, comprises a second

controlled switch 23, provided with a control terminal 24 and a resistor 25 connected mutually in series. The switches 20 and 23 preferably comprise Smart power MOSFETs, and are controlled in such a way that the switch 23 always keeps the load 25 connected during the measurement, so that there is always a current which eliminates surface charges (and therefore the effect of $V_p(t)$ can be neglected), whilst the switch 20 switches the suitable load 22 at the desired frequency, which is 100 Hz in the case considered.

The device 30 also comprises a circuit 40 for measuring the variation of the voltage drop across the load 12, one side of which is connected to the battery terminal 9 and the other side of which is connected to the intermediate terminal 41 between the load 12 and the branches 11, 15, and a circuit 42 for measuring the variation in the battery voltage, connected to two signal lines 43 and 44, which end at the battery terminals 8 and 9. The circuits 40 and 42 may be formed, for example, by the cascade connection of an operational amplifier, which determines the differential voltage at its ends, comprising a rectangular wave with a frequency equal to the switching frequency of switch 20 (100 Hz), and a take-off stage for the peak-to-peak range. The outputs of the measuring circuits 40 and 42 are connected to the respective inputs of an A-D converter 45, which also operates as a multiplexer. The output of the converter 45 is connected to a line 50 (Figure 3), to supply the processing unit 51 alternately with the values V_L and V_b ; this therefore enables the unit 51 to calculate the value of the internal resistance R_I based on (9) which is sought.

As can be seen from Figure 3, the unit 51 is also connected via a unidirectional output line 52 to the measuring device 30 for sending the control pulses from the switches 20 and 23, as well as via a unidirectional output line 54 to a display unit 53 for displaying the value of the calculated internal resistance. In Figure 3, the measuring device 30 is shown provided with a pair of lines 55 and 56 which each end in a respective clamp 57 for connecting to the output terminals of the battery 2.

The operation of the device illustrated will now be described with reference to Figure 4, which relates to the flow diagram of the phases effected by the unit 51.

Initially (Block 60) the unit 51 obtains via the line 50 the value of the variation of the voltage of the battery V_b , measured by the unit 40 in the manner described above, then (Block 61) the same unit 51 obtains the value of the variation of the voltage across the load V_L , measured by the unit 42. Then the unit 51 obtains the value of the resistance R_L (governed by a memory allocation, for example - Block 62), and finally calculates the value of the internal resistance R_I based on (9) in relation to the variation of the voltage drop of the battery and the variation of the voltage drop across the load, parameterised with respect to the resistance of the load (Block 63).

The advantages which can be obtained from the measuring device described are the following. First of all, the device 1 permits an accurate determination of the value of the internal resistance, and is then able to provide the numeric value via the display unit, without requiring a needle instrument to be read. Moreover, the device described does not involve a high power dissipation. In fact, with a circuit where the resistance of the load 12 is 10 Ω , and resistors 25 and 22 are 8.2 and 50 Ω respectively, it is possible to obtain a current $I(t)$ between 200 and 700 mA.

Moreover, the use of the device does not require any particular skill or lengthy operations on the part of the operator, since it only requires the connection of the clamps 57 to the terminals of the battery; as for the remainder, the determination of the necessary quantities is effected completely automatically. Furthermore, with the device described it is possible to eliminate the effect of surface charges which would falsify the result of the measurement, thus obtaining the effective value of the resistance of the load.

The circuit for measuring the internal resistance is extremely simple and therefore has a high reliability and reduced dimensions and cost.

Finally, it is clear that modifications and variations can be made to the device described and illustrated without this leading to a departure from the protected scope of this invention. In particular, instead of referring all the operations relating to the control of the switching of the switches 20 and 23 to the unit 51, it is possible to provide a suitable logic circuit. Moreover, instead of providing the units 40 and 42, the digital values of the voltages V_b and V_L can simply be determined by the measuring device 30, and the determination of their variation due to the 100 Hz switching can be effected by means of the unit 51.

Claims

1. A device for measuring the internal resistance of batteries, particularly of motor vehicles, suitable for connecting to the terminals (8, 9) of a battery (2), characterised in that it comprises:
 - a resistive load (12) connected across the terminals (8, 9) of the battery (2) via switching means (11) suitable for switching the said load at a predetermined frequency, the said load having a predetermined resistive value (R_L), and generating at the terminals of the load a voltage drop (V_L) across the load which varies with the said predetermined frequency;

- suitable means (40) of determining the variation of the said voltage drop across the load;
 - suitable means (42) of determining the voltage drop (V_L) of the battery across the said terminals; and
 - suitable means (51) of calculating the internal resistance in relation to the said variation of the voltage drop of the battery and to the said variation of the voltage drop across the load, the said relationship being parameterised with respect to the said resistive value of the said load.
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2. A device according to Claim 1, characterised in that the said suitable means of calculating the internal resistance comprise a processing unit (51) connected to display means (53) for the digital representation of the said internal resistance.
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3. A device according to Claims 1 or 2, characterised in that the said switching means comprise a first branch (11) formed by the connection in series of a first controlled switch (20) and a first resistor (22), the said first controlled switch having a control terminal (21) suitable for receiving a digital open/close control signal having the predetermined frequency.
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4. A device according to one of Claims 1 to 3, characterised in that it comprises a circuit (15) for eliminating surface charges, connected in use across the terminals (8, 9) of the battery (2).
5. A device according to claim 3, characterised in that it comprises a circuit for eliminating surface charges, the said circuit comprising a second branch (15) connected in parallel with the said first branch (11) and formed by the connection in series of a second controlled switch (23) and a second resistor (25), the said second controlled switch having a control terminal (24) suitable for receiving a control signal suitable for keeping the second controlled switch closed during the determination of the variations of the voltage drops across the load and of the battery.
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6. A device according to Claim 5, characterised in that the said first and second controlled switches (20, 23) are formed as solid state switches.
7. A device according to one of Claims 2 to 6, characterised in that the said processing unit (51) comprises microprocessor means and that the said suitable means for determining the variations of the voltage drops across the load and of the battery each have a respective output connected to an analogue-digital converter element (45) and to a multiplexer having an output connected to the said microprocessor unit (51).
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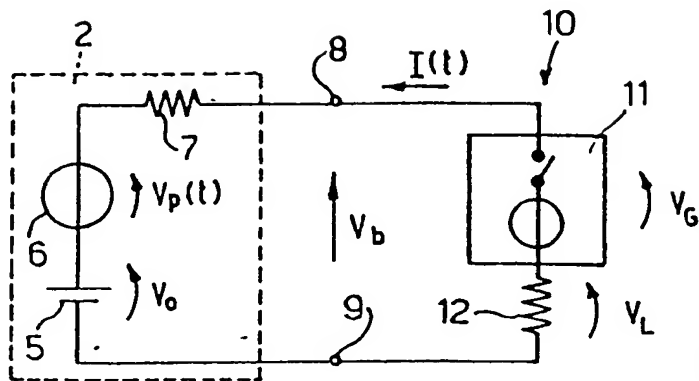


Fig. 1

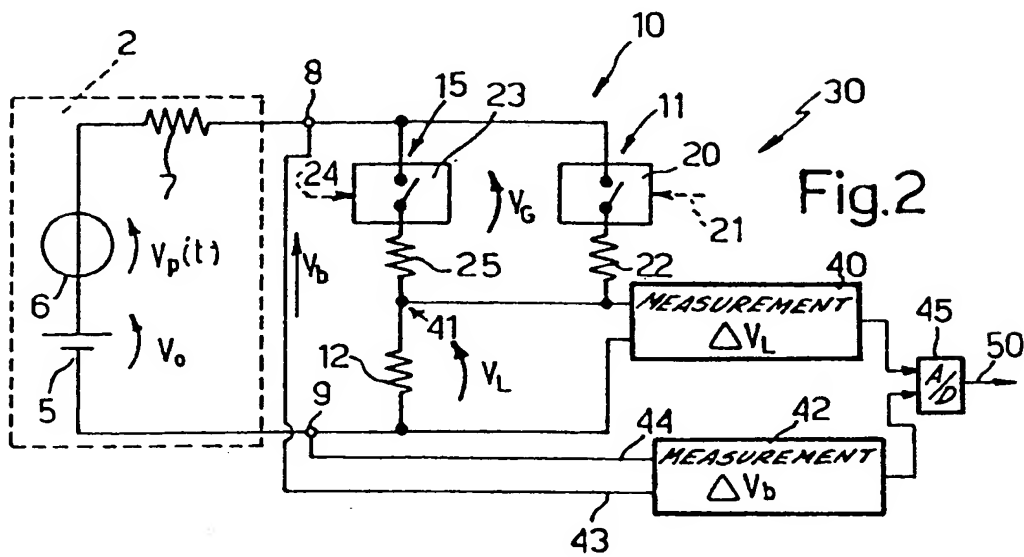


Fig.2

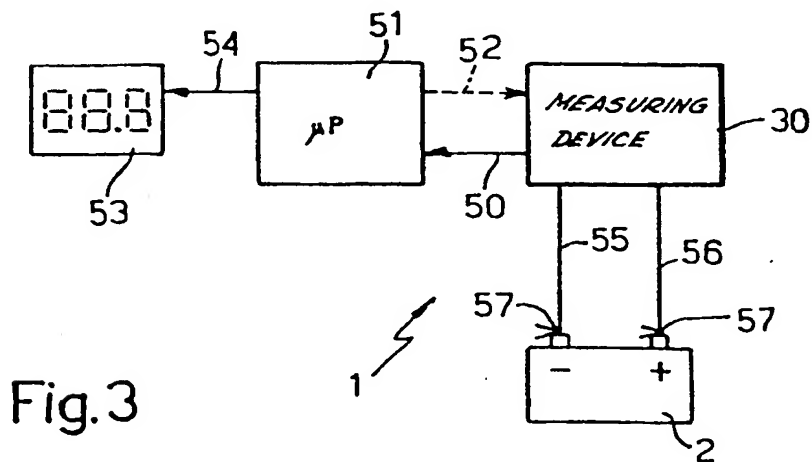


Fig.3

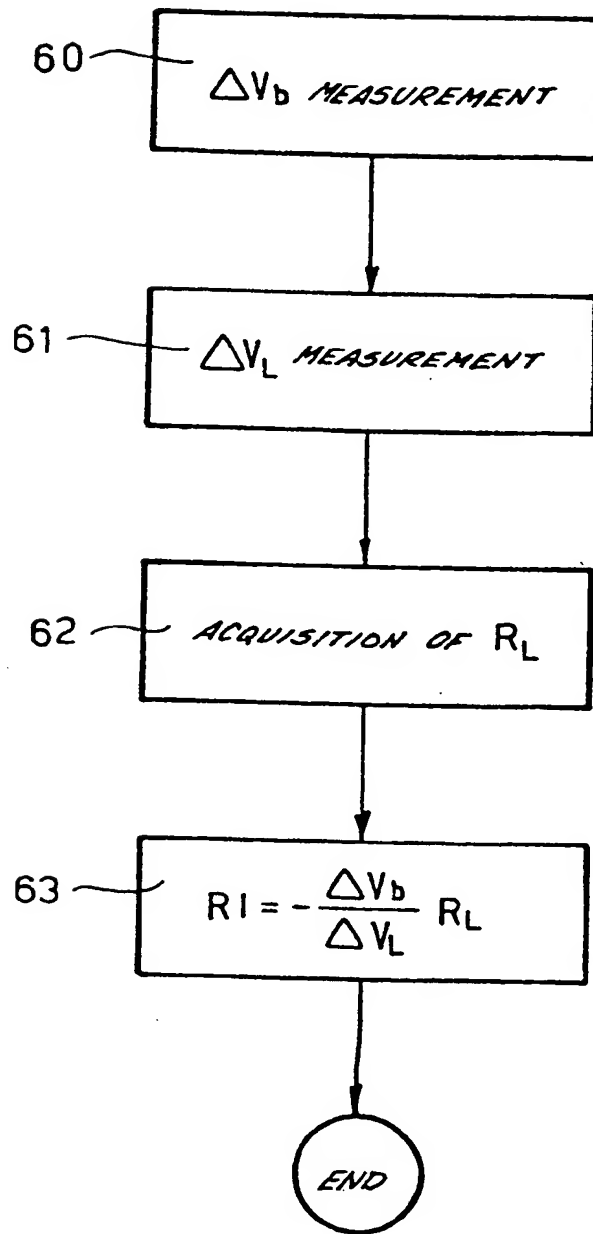


Fig. 4



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EUROPEAN SEARCH REPORT

Application Number

EP 92 11 8686

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 731 189 (SHARAF ET AL.) * abstract * * column 2, line 31 - line 42 * * column 6, line 59 - column 8, line 68; figures 5,6 *	1	G01R31/36
Y	---	2-7	
Y	WO-A-8 302 005 (BEAR AUTOMATIVE SERVICE EQUIPMENT) * page 5, line 21 - page 6, line 19 * * page 7, line 1 - line 12 * * page 10, line 31 - page 11, line 20; figure 2 *	2-7	
A	---	1	
X	PATENT ABSTRACTS OF JAPAN vol. 12, no. 53 (P-668)(2900) 18 February 1988 & JP-A-62 200 277 (SHIN KOBE ELECTRIC MACH) 3 September 1987 * abstract *	1	
A	WO-A-9 006 522 (GLOBE-UNION) * page 7, paragraph 1 * * page 13, paragraph 3 -paragraph 4; figure 7 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 984 762 (DOWGIALLO JR.) * column 3, line 18 - column 6, line 48; figures 2-6 *	1	G01R
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 08 FEBRUARY 1993	Examiner SINAPIUS G.H.
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